

A Research Platform for Urban Air Mobility (UAM) and UAS Traffic Management (UTM) Concepts and Applications

Quang V. Dao¹, Jeffrey Homola¹, Michele Cencetti², Joey Mercer¹,
and Lynne Martin¹

¹ NASA Ames Research Center and ² University Space Research Association
Moffett Field, CA USA
{quang.v.dao, jeffrey.r.homola, michele.cencetti, joey.mercer,
lynne.martin}@nasa.gov

Abstract. The purpose of this paper is to describe a research platform for the Urban Air Mobility (UAM) concept. UAM was conceived to enable on-demand air taxi service to commuters in metropolitan areas. At the NASA Ames Airspace Operations Laboratory (AOL) user interfaces have been developed to support small UAS operations for the UAS Traffic Management (UTM) project. Due to operational similarities between UAM and UTM, the UTM architecture offers a convenient starting point for research and development of UAM operations. Herein, we begin with an overview of the primary need and expectations characterizing concepts for modern air transportation systems, followed by a brief description of the UTM and UAM concepts. We then describe the UTM architecture, as well as the AOL's research platform and capabilities. The potential applications for UAM research and development are then discussed, providing some direction for future research efforts.

Keywords: UTM · UAM · UAS

1 Introduction

The purpose of this paper is to describe recent developments in NASA's Urban Air Mobility (UAM) research platform. At the NASA Ames Airspace Operations Laboratory (AOL) user interfaces have been developed and tested for simulated and live flight tests as part of the development of the UAS (Unmanned Aerial System) Traffic Management (UTM) concept. We begin with a brief overview of the UTM and UAM concepts. In the following sections we describe the UTM architecture, as well as research platform and capabilities. The potential applications for UAM research and development are then discussed, providing some direction for future research efforts.

The UAS Traffic Management concept was designed to enable small UAS (sUAS) under 23 kg and low altitude operations – only occupying airspace from the surface up to 152 m in altitude [1]. Use cases explored for UTM include: film and media, survey work, emergency response, and commercial package delivery. At the center of the UTM ecosystem is an information exchange system that allocates active traffic management of aircraft to automation and provides services to UAS operators for coordinating shared access to airspace [2]. All of these services are designed to support UAS operators who submit reservation requests, via a client interface, to their chosen USS (UAS Service Supplier) for operations within specified volumes of airspace.

Urban Air Mobility (UAM) is a concept for high-tempo, safe and efficient on-demand air transport services in and around metropolitan areas [3]. Characteristics of UAM operations expected from industry include low cruise-altitudes between 152 m and 1,524 m above ground level and single trip ranges of less than 100 km [4]. Although the UAM concept can be extended to other operations, such as rescue missions, news gathering, and package delivery, we highlight a popular industry use case - passenger transport. UAM offers a technological solution to surface traffic congestion in overcrowded cities by enabling the distribution of that traffic to the air. However, in order for this distribution to be effective, in addition to achieving economy of scale, many challenges have to be met – these include an air traffic management system that can scale to high density operations. As the UAS Traffic Management concept was created to address high density operations by introducing automation for traffic management as part of its original design, its information exchange architecture is a convenient starting point for exploring UAM [3]. In the next section we provide an overview of this architecture.

2 UTM Information Exchange Architecture

We provide a brief description of the UTM architecture here. Readers are encouraged to see Rios et al. [5] for more technical details.

UAS Service Supplier (USS). The UTM architecture is based on a number of different commercial USSs that support operations, providing all the services that the UAS operators need to safely manage their systems. The USS provides different functions, including support for operations planning, de-conflictions and conformance monitoring. The interaction between USSs and the UAS operators enables the flow of information across the USS network, and to promote shared situational awareness among UTM participants. In particular, USSs support an efficient and safe use of the airspace, helping operators to meet UTM operational requirements. In addition, the UTM system can make information about UTM activity, such as emergency response operations, available to existing airspace users.

Supplemental Data Service Provider (SDSP). SDSPs provide data in addition to data already available from USSs, e.g., weather and terrain. SDSP services are available directly to USS as well as to operators.

Flight Information Management System (FIMS). The FIMS serves as a bridge between the UTM ecosystem and the commercial air traffic management (ATM) system. Through this system, the USS can identify and apply airspace usage restrictions, e.g., no drone operations over national parks and military operations areas.

3 Airspace Operations Lab (AOL) Capabilities

While the UTM core services discussed above were developed as part of the initial vision, the Airspace Operations Lab (AOL) at NASA Ames has developed additional data management services specifically to support research related activities. In general, these services process and validate raw data from UAS operators, as well as serve as tools for developing and propagating traffic scenario data for simulations. We describe them below.

USS Data Collector (UDC). The UDC enables the real-time logging of information relevant to UTM operations, messages and position reports; the data is then stored for later analyses or other post-processing activities. This element and the USS share the same interface, except the UDC does not apply any filtering to incoming raw data.

FEP Extensible Proxy (FEP). The FEP provides data for real-time, near real-time and past operations. A playback capability that utilizes FEP products allows researchers to run past scenarios for testing and demonstration purposes with data collected during actual flights and simulated tests.

AOL USS. The AOL USS is an in-house capability for internally testing various UTM applications. To maintain consistency with external USSs, it was designed against publicly available implementation guidelines. This allows the AOL to test prototype tools and ensure their reliability before connecting with partner USSs in collaborative simulations and live flight tests.

MPI UTM Message Broker Linear Integrator (MUMBLI). MUMBLI enables the exchange of traffic information between UTM and air traffic management (ATM) systems, so that aircraft position and flight information can be presented across displays from either system.

3.1 Displays and Tools

The products of these services are presented on displays that serve primarily as research visualization tools, but also represent what might be used to support various human roles when UTM is implemented in the future. To support mission control activities and technical demonstrations, these tools and displays have been repeated on a video wall and across various areas throughout the AOL (Fig. 1).



Fig. 1. Video wall with UTM displays.

Google Earth Gateway (GEG). Google Earth is used to visualize UTM flight data, e.g., flight paths, operational volumes, USS area coverage, in a 3D environment. Data are provided in real-time from FEP and they are used to populate the 3D environment with UAS targets. Google Earth Gateway provides a set of user controls to enable/disable the visualization of graphical features, e.g., point of view and flight volume visualization.

Insight UTM (iUTM). iUTM (Fig. 2) was designed to be a mobile device application providing observers out in the field with situation awareness. This application displays vehicle position(s) and operational boundaries as an overlay on 2-Dimensional maps. A user can also navigate to a table that provides a list of all known operations. The table can be filtered or sorted by vehicle ID, operational state (e.g., currently in-flight or landed), take-off time, and landing time.



Fig. 2. iUTM mission table page on left and operation volumes over 2-Dimensional maps on the right.

Situation Display (SD). The Situation Display (Fig. 3) is similar to the iUTM. As a desktop application, greater screen real estate affords presenting both the table and map side-by-side, making it easier to relate UTM operational data to specific events over a geographical location. This display can be configured to support, for example, an air navigation service provider (ANSP) or a fleet manager. The SD is ideal for paring down airspace to track specific operations, but would suffer from clutter with high traffic density. For monitoring high density operations, we turn to the Grafana Dashboard (below).

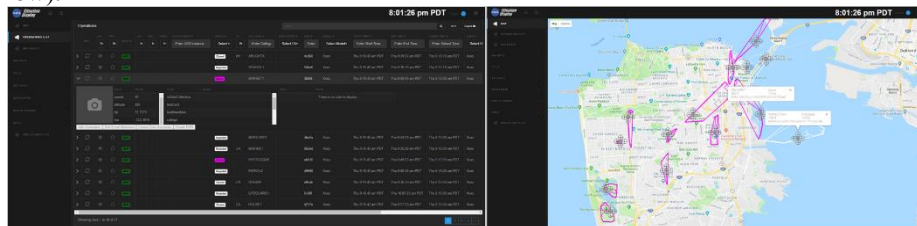


Fig. 3. Situation Display (SD) – operations table on left and map with corresponding aircraft targets on right.

Grafana Dashboard. This dashboard is an emerging and flexible framework for examining distributed and web-based interfaces for visualization of UTM information. This framework segregates the data-source layer from the visualization layer. In the data-source layer, Django/Python web-development frameworks were implemented to

manage all the data exchanges and back-end operations. JavaScript is used to develop the visualization layer and all the corresponding modules.

A set of dashboards for data visualization and monitoring has been developed on top of this framework. Custom plugins and panels have been implemented to support the visualization needs of the laboratory, exploiting the modularity and re-usability of the framework. The Grafana Dashboard end product is used to navigate historical data as well as provide real-time information (Fig. 4).

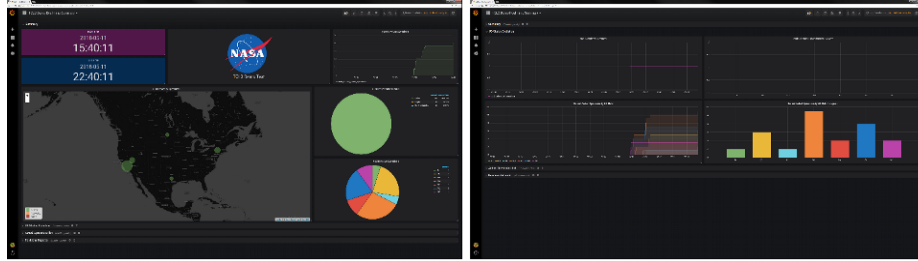


Fig. 4. Example screenshots of the real-time interface, showing 2D map, pie chart and histogram panels.

Augmented Reality Cave. To address public trust and UTM, the AOL has developed the Augmented Reality Cave to test applications for remotely identifying UAS operations. The system is composed of three 126" displays that provide a street view perspective of actual test site locations, and HoloLens for augmented reality features. One particular use case would be to simulate UTM operations over urban areas, and then develop the HoloLens to identify a flight within the scene and request information from UTM about the operation. What information will be available to the public will most likely be based on a minimal set of requirements that will be contingent upon the situation and company policies. The Augmented Reality Cave can be used to determine how the quality and quantity of information can impact trust and perceived transparency.

Aeronautical Datalink and Radar Simulator (ADRS). The ADRS [6] was originally designed to be an information exchange hub for manned commercial air traffic simulations. It provides validation, storage, and processing of data (i.e., aircraft state and trajectory information) and distributes requested information to clients and across servers. Multiple ADRS processes can be run simultaneously for greater information sharing, as well as expand the simulation environment. In human-in-the-loop simulations, ADRS provides traffic data for flight deck and air traffic control displays.

Multi-Aircraft Control System (MACS). Through ADRS, MACS has traditionally been used to display manned commercial air traffic in its flight deck and air traffic controller display modes [6]. MACS also provided the ability to develop traffic scenarios and simulate large transport commercial airspace systems. In order to simulate UTM operations, these scenario-editing capabilities were extended to enable the design and development of traffic scenarios for UAS operations, including the use of UTM operational volumes. MACS also includes a client interface for submitting volume reservation requests to the AOL USS. Together, MACS and the AOL-USS provide the ability to simulate multiple UTM operations. These simulated flights can be explored in isolation, or as part of a distributed flight test, integrating simulated and live operations.

4 Conclusion

High-tempo and high-density operations necessitating the allocation of traffic management to automation and the decentralization of services supporting those operations are key characteristics of the UAM concept [3]. In sharing these characteristics with UTM, the architecture and applications described above can be leveraged to support future UAM research. From the perspective of exploring roles and responsibilities, the Situation Display and Grafana Dashboard can be configured to examine information requirements and shape tasks for fleet manager or ANSP roles. For example, a measurable advantage of the Grafana Dashboard over the SD when testing against fleet manager tasks may suggest that the role is a highly supervisory one. MACS can be used to rapidly prototype and run simulations to test various airspace design concepts. For example, vertiports can be inserted as endpoints in a network of air taxi routes and shown as airports on an ATC display or SD. In conjunction with the MUMBLI and ADRS capabilities, both commercial and UAM traffic can be displayed simultaneously across different displays in a distributed simulation to investigate interactions between the two airspace systems. From the flight deck, the iUTM can be used to provide UAM pilots with overall awareness of the airspace, as well as view status information about their mission reservation requests. How UAM operational information might be integrated into the flight deck and what minimal amount of information might be required for effective operation of the vehicle are potential areas of research where the iUTM display can play an important role as a research capability.

5 References

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